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STUDY DOCUMENT NUMBER 2. METHODOLOGY FOR A STUDY OF THE ECONOMIC IMPACTS OF SULFUR OXIDE REGULATIONS IN OHIO

ENERGY AND ENVIRONMENTAL ANALYSIS, INCORPORATED,
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16. ABSTRACT

This report is the second volume in support of the Inflation Impact Statement for sulfur dioxide regulations prepared by the U.S. Environmental Protection Agency, in the Ohio State Implementation Plan. The Technical Support Document, Volumes I and II may be obtained through the National Technical Information Service EPA 905/2-76-002, PB-257 694 and PB-257 695.

This document provides an overview of the study methodology, illustrates the depth of analysis contained in the study, and provides a summary of the methodological content of succeeding study documents.

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Methodology for a Study of The Economic Impacts of Sulfur Oxide Regulations in Ohio

Part of a Study of the Economic Impact of Sulfur Regulations Promulgated by the U.S. Environmental Protection Agency for Ohio on August 27, 1976

Prepared for:

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Office of Air Quality Planning and Standards
United States Environmental Protection Agency

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SECTION I

PURPOSE

This document provides an overview of the methodology employed to estimate the economic impact of sulfur oxide regulations developed by the U.S. Environmental Protection Agency (EPA) for the State of Ohio. This document is intended to convey:

- the content of the various background documents
- the analytical approach employed
- a grasp of the level of sophistication and detail addressed in this study.

Figure 1-1 contains a listing of the ten documents which comprise the Inflation Impact Statement and its supporting reports.

These reports were based on the work of four EPA contractors whose contributions are outlined below.

Energy and Environmental Analysis, Inc.

- development of overall study methodology and preparation of document #2
- IIS (document #1)
- Industry Economic Impact Study (document #4)
- Energy Impact Study (document #5)
- Utility Cost Minimization (document #6)
- Coal Prices (document #10)
- Industry Cost Minimization (document #7)

Temple, Barker and Sloan

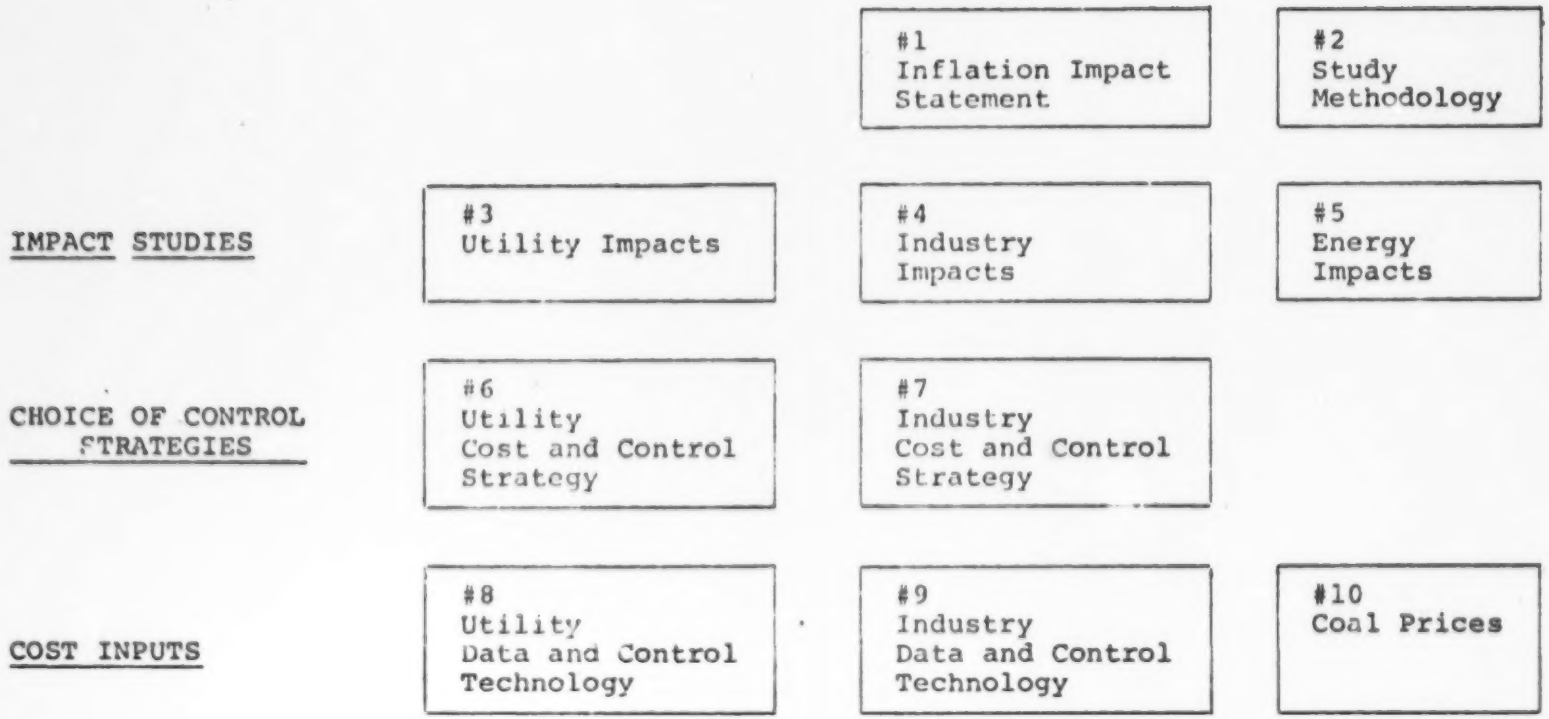
- Utility Price and Financial Impact Analysis (document #3)

PEDCO Environmental Specialists

- utility costs for pollution control equipment and coal conversion equipment
- basic plant data parameters (document #8)

Figure 1-1

INFLATION IMPACT STATEMENTS SUPPORTING DOCUMENTS



Battelle Columbus Laboratories

- cost algorithms for pollution control equipment for industry
- basic data on industrial boilers in Ohio (document #9)

The discussion below relates the study methodology and resulting analyses to the ten documents.

SECTION II

METHODOLOGICAL APPROACH

A. Level of Analysis

The final output of the study, summarized in the IIS, focuses on price, output, employment, energy and financial impacts of the proposed and final sulfur oxide regulations. An early decision was made to analyze impacts at the plant level in both the utility and industrial sectors. In the utility sector this was necessary in order to provide credible cost of control estimates since such estimates are a function of plant and stack specific parameters such as fuel consumption or capacity. In addition, since impacts were to be developed separately for major utility systems in Ohio, estimates of capital and operating costs at the plant level were essential.

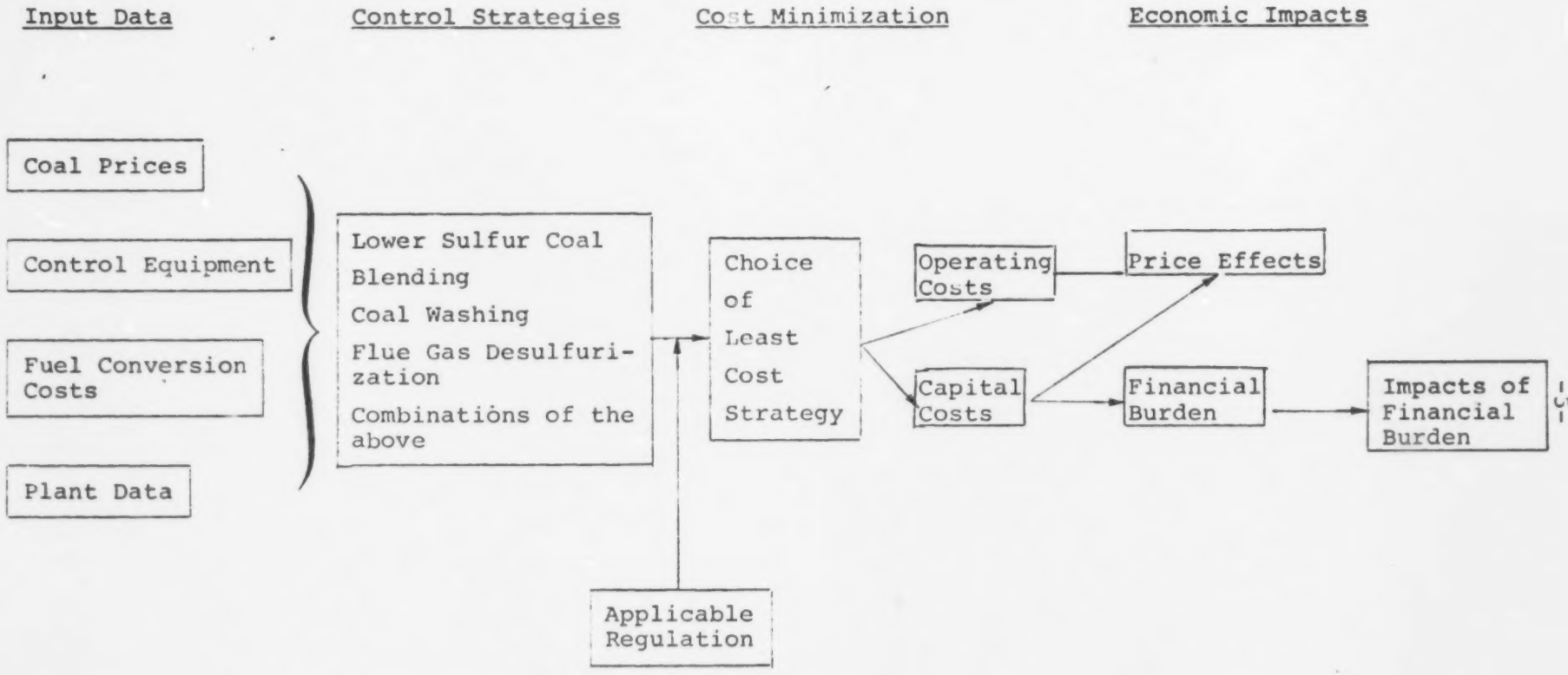
Analyses at the plant level for the industrial sector are rare both due to the difficulty of obtaining reliable data and the conventional presentation of average impacts by industry group, e.g., average price increases for steel plants. However, in this study average impacts were expected at the outset to be negligible. Using price impacts as an illustration, of 20 plants in a given industry, only 10 might be out of compliance (thereby incurring some costs) and perhaps only 4 might incur significant price effects, e.g., 5-10 percent. A sales weighted average for all plants in the industry would show a price effect of less than 1 percent, leading to a potentially misleading conclusion of no significant impacts. Since the study goal was to identify (following this illustration) that 4 plants were impacted, it was essential to derive the distribution of impacts among affected plants rather than to rely on estimates of average impacts.

B. Analytical Elements

Figure 2-1 is a schematic diagram of the analytical elements

Figure 2-1

Methodology - Utilities



used to derive economic impacts for the electric utility industry.

1. Basic Data

Data were collected for the purpose of estimating costs separately for each power plant stack. These data elements included:

- stack and plant specific parameters which could affect costs (e.g., megawatt capacity, capacity utilization, age)
- estimates of the delivered costs of coal of various sulfur contents to each plant
- costs of converting from one type of coal to another (e.g., boiler modifications, derates)
- costs of pollution control equipment for flue gas desulfurization systems and particulate control equipment[1/]

These inputs were used to derive capital and operating costs for various alternative means of meeting specified sulfur oxide emission limits.

2. Alternative Control Strategies

The above inputs were combined to generate costs for several alternative means of complying with applicable regulations:

- switching to a lower sulfur coal
- blending new supplies of low sulfur coal with existing coal
- coal washing at the power plant or near the coal mine
- installation of flue gas desulfurization (FGD) equipment
- combinations of the above strategies

1/ Particulate control must be upgraded if the plant switches to a lower sulfur coal.

Some of the factors considered in developing the cost of these systems include: fuel cost differentials by sulfur content, costs of upgrading particulate control, power penalties for FGD and particulate control equipment, costs of blending facilities, boiler or pulverizer derates due to fuel switching, costs of replacement capacity and added steam demands to operate FGD units.

Since the precise form and levels of the final sulfur oxide regulations were unknown at the start of the study, cost curves (annual and capital costs as a function of various sulfur emission rates) were developed for each control strategy. These curves were developed for each stack since emission regulations could vary among stacks at the same plant.

3. Utility Cost Minimization

For each power plant, costs were then determined for a specified emission limit or set of stack specific emission rates. This cost minimization step was keyed to the criteria approximating minimization of the discounted (over 20 years) annual cost of complying with the regulation.[1/] This algorithm selected the least cost strategy (e.g., FGD) as well as the level of sulfur removal required to achieve the regulation. This choice of control strategy provided not only annual and capital costs but outputs including relevant energy penalties and shifts in the sources of coal supply among producing regions.

4. Utility Economic Impacts

The costs calculated above were then converted to meaningful indicators of economic impact. This was accomplished by the generation of a baseline forecast of consumer charges and capital requirements for each utility system. Costs were then aggregated for the plants owned by each utility system, accounting for joint

1/ Annual costs include all operating costs plus the annualized cost of capital, and a rate of return on equity.

ownership of facilities, to show the incremental increase in consumer charges for electricity and the percentage increase in capital requirements estimated for compliance with the sulfur oxide regulations. An evaluation was then made of each utility system's ability to finance these added investments in terms of factors such as internal versus external sources of funds and resultant changes in financial viability parameters such as debt equity or interest coverage ratios.

5. Non-utility Sectors

A similar methodology was applied to the industrial sector. Costs for industrial boilers were calculated using the same logic as Figure 2-1 while cost curves for industrial processes (refineries, coke ovens, sulfuric acid plants, etc.) were generated using the most likely control technologies.

The product of this sector study addresses the impacts of regulations on product prices for manufacturing firms and subsequent production and employment impacts. Financial burdens are also assessed and potential plant shut-downs are identified. For institutions such as hospitals, the analysis is confined to presenting the estimated impact of fuel cost increases on operating budgets.

The potential price impacts of these cost increases are evaluated at the plant level in a series of screening steps of increasing sophistication. This evaluation process combines plant specific data (such as energy consumption or annual production) with state or national parameters to develop approximate estimates of the value of sales at the plant level. The estimated costs of compliance with sulfur oxide regulations are then compared to sales to estimate price impacts. For those industry sub-groups where significant price increases are anticipated, a followup analysis is conducted to evaluate potential output and employment effects. This analysis includes such factors as:

potential competition from neighboring states, relative severity of the Ohio regulations, the number of employees that might be affected, the nature of the product market, general trends in the affected industry and plans already underway to install pollution control equipment as a consequence of state or local regulations.

Capital requirements for pollution control devices at the plant level are aggregated to corporate level in order to evaluate a firm's ability to finance the estimated investment requirements. These incremental capital expenditures are compared for significance with normal annual business investment expenditures. Where pollution control investments constitute a significant increase in overall capital requirements, the firm's capability to finance the additional expenditures is discussed. Older, economically marginal plants are identified where firms may elect to speed up phaseout schedules rather than incur the capital expenditures necessary to comply with applicable regulations.

6. Energy Impacts

The study also discusses the energy implications of the probable control strategies selected by utility and industrial plants to comply with the sulfur oxide regulations. The shift in coal production patterns under the proposed and final regulations for both utilities and industry are analyzed. The impact on coal production includes the effect of such factors as energy penalties due to environmental control equipment, energy lost in the coal washing process, capacity derates when western coal is the control strategy choice, the shift in coal demand by sulfur content and the potential for coal-to-oil switching in the industrial sector. The report focuses on the expected change in coal production destined for Ohio markets, especially impacts on areas, such as Ohio, producing higher sulfur content coal.

SECTION III

SUPPORTING DOCUMENTS

This section contains a brief summary of the contents of each of the documents supporting the Inflation Impact Statement shown in Figure 1-1. In order to emphasize the interdependence of the documents, the discussion is organized into four parts:

- coal prices (document #10) are covered first since they are key inputs in all subsequent analysis
- utility economic impact (documents #3, 6 and 8)
- industry economic impact (documents #4, 7 and 9)
- energy impacts (document #5)

A. Coal Prices (document #10)

1. Outputs

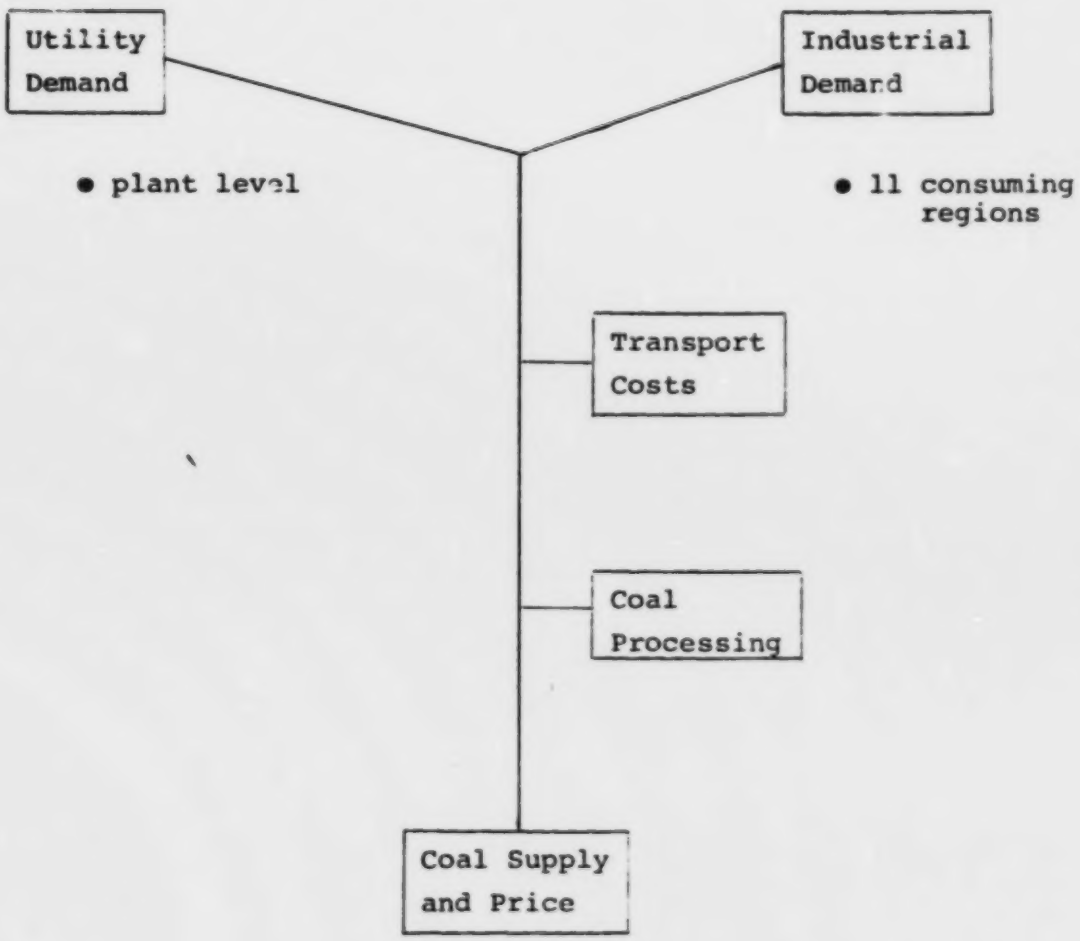
The costs of sulfur emission limits are critically dependent on the price premium low sulfur coal will command over relatively high sulfur coal. This backup document presents the coal prices used in the study and the method of deriving these prices. These prices are inputted into the utility and industrial cost minimization models to generate control strategy choices and costs of compliance. This appendix also establishes baseline and impact scenario origin-destination patterns so that the impacts of sulfur regulations on the quality and sources of coal production can be determined in the Energy Impact Report (document #5).

2. Report Content

The nature of the outputs of this report is depicted in Figure 3-1. FOB mine prices for coal are determined for seven production regions:

Figure 3-1

Coal Prices and Origin-Destination Patterns



- Ohio
- Pennsylvania
- Northern West Virginia
- Southern West Virginia and Eastern Kentucky
- Western Kentucky and Indiana
- Utah and Colorado
- Northern Great Plains

These prices are estimated for six sulfur content categories. The study evaluated alternative price premiums for lower sulfur coal in terms of:

- extrapolation of current price trends
- estimates of price premiums based on a national coal model[1/]
- the pace of new mine openings
- the level of demand and the stringency of sulfur emission requirements in other states

Once FOB mine prices of raw coal were determined, coal processing (or washing) was assessed as a means of reducing the sulfur content of the delivered product. After evaluations of processing costs and sulfur reduction potential in each producing region, a revised set of prices of available coal by sulfur content was then prepared.

Transportation costs were then determined by existing rail, barge and truck rates. For utilities transport costs were estimated from the most likely shipping point in each producing region to each plant. These costs were based on:

- actual transport mode links to the plant
- freight rates applicable (unit trains, single car, multiple car)

1/ This model provides an approximation to market determined coal prices by sulfur content for 19 coal producing regions.

- selecting the least cost transit mode from each producing region

For industry, the destination point for these calculations was a regional centroid[1/] rather than a plant. Eleven such demand regions were developed for industrial consumers.

This output provides a set of coal prices by sulfur content and producing region available to each utility and industrial plant. These prices and origin destination links became inputs into the control strategy selection models (documents #6 and 7) for the utility and industrial analyses.

B. Utility Impacts

The impact of proposed and final sulfur oxide regulations on the electric utility industry in Ohio is summarized in document #3 with documents #6 and 8 providing control strategy choice and cost data.

1. Outputs

The product of this sector study addresses the impacts of regulations on electricity prices paid by consumers and on the utilities' ability to finance these incremental expenditures for pollution control without serious repercussions in terms of further rate increases or postponements of new generating facilities to meet future power demands in Ohio and neighboring states. The impact assessments (presented in document #3) are in turn summarized in the IIS (document #1).

Other outputs of the utility analysis relating to control strategy selection and resultant shifts in coal usage patterns are key inputs in the Energy Impact Report (document #5) as well as in the Utility Economic Impact Assessments (document #3).

1/ This refers to the focal point of a major transportation system from which distribution of goods emanates.

2. Basic Data (document #8)

This report contains two sets of information on each plant. Descriptive information for each plant was provided at the stack level of detail: megawatt capacity, firing rates, fuel usage, sulfur content, age of units, etc. The second set of data relates to the cost of achieving sulfur emission limits including pollution control equipment as well as costs related to shifting from a high to a lower sulfur content fuel. All basic cost data are reproduced in this report except coal prices (which were derived in document #10). This report also includes a brief discussion of the sources and logic behind the cost data.

3. Cost Minimization Report (document #6)

This report describes the methodology used in the selection of control strategies and calculation of control costs. The underlying logic was described briefly in Section II of this document. Key elements in this logic include:

- minimizing discounted cash flow of control costs
- selection of optimal control strategy subject to plant wide constraints
- generating estimates of control costs and energy impacts for each plant

The factors taken into account in the cost algorithms are summarized in Table III-1 for each control strategy.

Table III-1

Factors Influencing Costs

Common to All Control Options (stack specific)

- remaining life
- design capacity
- firing rate
- existing sulfur content
- capacity utilization rate
- coal consumption
- applicable regulation
- existing coal price
- plant size

Low Sulfur Coal

- boiler or pulverizer modifications
- boiler derate
- particulate control equipment
- power penalty of particulate control requirement
- price of low sulfur coal

Flue Gas Desulfurization

- two systems evaluated (Wellman-Lord and Lime/limestone)
- power penalty
- steam penalty
- sludge removal
- plant economies of scale
- degree of sulfur removal required

Blending

- same as low sulfur coal
- blending facility costs
- blending facility power penalty

Table III-1 (cont'd)

Coal Cleaning (at the plant)

source of coal
degree sulfur removal required
coal energy losses
plant size
power penalty

Combination Options

all of the above

In order to illustrate the logic of the control strategy selection process, a simplified description of the steps in the selection process is outlined below for the low sulfur coal alternative.

- The appropriate emission limit is determined for each stack in the plant.
- For the low sulfur coal control option, the most stringent stack regulation becomes binding for all stacks.[1/]
- The algorithm searches for the lowest cost coal with a sulfur content equal to or better than the most stringent stack specific emission regulation.
- For coal from the Northern Great Plains, a plant specific estimate of the probable capacity derate[2/] is used to make the following adjustments:

  - plant fuel throughput in BTU's drops
  - fuel costs related to emission control are determined[3/]
  - the operating and capital costs of new capacity to replace electricity output lost due to the derate are added
  - costs of modifying boiler facilities are included

- The algorithm then selects between Northern Great Plains and other complying coal.
- Capital and operating costs of upgrading particulate control equipment (a function of the degree of sulfur removal implied by the regulations) are calculated.

1/ This example depicts the case where the plant is restricted to one coal pile, thus forcing all stacks to utilize the same sulfur content fuel. The analysis was actually conducted for both one and two coal piles.

2/ Due to limits on pulverizer or boiler capacity as a consequence of the lower heat value of western coal or other quality distinctions.

3/ Fuel costs in this case are equal to the price differential per million BTU's between western coal and existing coal times the fuel use after derating minus the operating cost savings due to the reduced BTU energy throughput at the affected plant.

- Costs are adjusted to account for Allowance Funds During Construction (AFDC) taxes and price increases over the planning period.
- Capital costs are then converted into annual costs over remaining plant life accounting for costs of equity, debt and depreciation.
- The discounted value of the annual capital, operating and fuel costs for the lower sulfur control option is then compared with the costs of other control alternatives.

The Cost Minimization Report also contains for the proposed and final regulations summary results for:

- the capital and annual costs of control
- compliance status
- the mix of control strategies selected

These data become the basic input to the Utility Economic Impact Report (document #3) which translates these costs into electricity price increases and financial demands. In addition, the energy implications of the control strategies provide the utility inputs into the Energy Impact Report (document #5).

4. Utility Economic Impact Report (document #3)

This analysis converts the capital and operating cost data generated in the Cost Minimization Study (document #6) into price and financial impacts.

Electricity price impacts are calculated in terms of an average for Ohio utilities and separately for the eight investor-owned companies with significant generating capacity in Ohio. The estimates are prepared using a cost accounting algorithm which reflects typical utility practices and electricity rate setting procedures. Increases in operating revenues

required to cover pollution control costs are then compared to a baseline estimate of revenues (derived from utility company specific data sources) to estimate the resultant increases in electricity prices charged to consumers.

In a similar manner the capital costs of sulfur emission and associated control equipment are compared to baseline investment demands for each investor owned utility company to derive the percentage increase in capital expenditures which would result if control equipment must be in place by 1980. A company specific analysis was then performed focusing on that company's ability to finance the incremental investment demands. This decision covered:

- required increases in external financing
- effects on parameters reflecting financial inability (dividend payment rates, debt equity ratios, etc.)
- other investment plans which may have to be delayed
- actions such as accelerated electricity rate increases or declines in rates of return to stockholders to assist financing problems

The outputs of this study are subsequently summarized in the Inflation Impact Statement (document #1).

C. Industry Impacts

The impact of proposed and final sulfur oxide regulations on manufacturing establishments and institutions (e.g., hospitals, military installations) is summarized in document #4 with documents #7 and 9 providing control strategy choice and cost inputs.

1. Outputs

The product of this sector study addresses the impacts of regulations on produce prices for manufacturing firms and subsequent production and employment impacts. Financial burdens are also assessed and potential plant shut-downs are identified. For institutions such as hospitals, the analysis is confined to presenting the estimated impact of fuel cost increases on operating budgets.

The impact assessments (presented in document #4) are in turn summarized in the IIS (document #1). Energy implications of shifts in fuel quality or possible conversions from coal to oil are key inputs into the Energy Impact Report (document #5).

2. Basic Data (document #9)

This report contains basic data on the parameters of steam generating boilers in the state of Ohio. This data is provided at the stack and boiler levels and includes such factors as fuel type, fuel consumption and design firing rates. In addition, this report contains cost algorithms for flue gas desulfurization and industry specific process controls (e.g., coke oven gas, sulfuric acid, oil refineries, sulfur recovery plants). Deficiencies and assumptions underlying this data are also briefly discussed.

3. Cost Minimization Report (document #7)

This report describes the methodology used in control strategy selection and control costs. The underlying logic was described

briefly in Section II of document #9. Contents of this report include:

- description of industrial process sources covered including fuel combustion sources, chemical processes, plants burning fuel gas containing hydrogen sulfide
- modifications to the cost algorithms developed in document #9
- parameters used such as depreciation formulae and cost of capital
- a discussion of plants excluded due to data limitations
- data sources for plant characteristics of industry specific process technologies

4. Industry Economic Impacts (document #4)

This document converts the basic cost data generated in the Cost Minimization Report (document #7) into measures of price, output, employment and financial impact. It contains a review of the number of industrial sources covered in the study, identifying reasons for exclusion (such as where natural gas is the only fuel used at a plant). It also contains a brief summary of the proposed and final regulations, emphasizing the differences in the final regulation in terms of county coverage, regulation structure and plant specific regulations. The number of plants out of compliance and associated control costs in each industry are presented.

The potential price impacts of these cost increases are then evaluated at the plant level in a series of screening steps of increasing sophistication. This evaluation process combines plant specific data (such as energy consumption or annual production) with state or national parameters to develop approximate estimates of the value of sales at the plant level. The estimated costs of compliance with sulfur oxide regulations are then compared

to sales to estimate price impacts. For those industry subgroups where significant price increases are anticipated, a followup analysis is conducted to evaluate potential output and employment effects. This analysis includes such factors as: potential competition from neighboring states, relative severity of the Ohio regulations, the number of employees that might be affected, the nature of the product market, general trends in the affected industry and plans already underway to install pollution control equipment as a consequence of state or local regulations.

Capital requirements for pollution control devices at the plant level are aggregated to the corporate level in order to evaluate a firm's ability to finance the estimated investment requirements. These incremental capital expenditures are compared for significance with normal annual business investment expenditures. Where pollution control investments constitute a significant increase in overall capital requirements, the firm's capability to finance the additional expenditures is discussed. Older, economically marginal plants are identified where firms may elect to speed up phaseout schedules rather than incur the capital expenditures necessary to comply with applicable regulations.

D. Energy Impacts (document #5)

1. Outputs

This report summarizes the energy implications of the proposed and final regulations. Since coal is the predominant fuel used by affected plants in both the utility and industrial sectors, the report focuses on shifts in the pattern of coal production likely to occur as a consequence of the control strategies selected.

The output of this report is summarized in the IIS (document #1). The energy impacts discussed in this report are based on

the control strategies and coal origin-destination patterns generated in the cost minimization reports for the utility and industrial sectors (documents #6 and 7) as well as the discussion of coal prices which is presented in document #10.

2. Energy Impact Report Content

The report begins with a review of the current fuel consumption by all sectors in Ohio, emphasizing the almost exclusive use of coal by the utility sector and a lesser reliance on coal by industry due to its consumption of relatively low cost natural gas supplies. Current coal consumption patterns are identified in terms of sulfur content and originating production regions.

The shift in coal production patterns under the proposed and final regulations for both utilities and industry is presented. The impact on coal production includes the effect of such factors as: energy penalties due to environmental control equipment, energy lost in the coal washing process, capacity derates when western coal is the control strategy choice, the shift in coal demand by sulfur content and the potential for coal-to-oil switching in the industrial sector. The report focuses on the expected change in coal production destined for Ohio markets, especially impacts on areas, such as Ohio, producing higher sulfur content coal.

APPENDIX A

INFLATION IMPACT STUDY DOCUMENTATION

This appendix identifies the documents prepared to support the Inflation Impact Analysis of the sulfur oxide regulations prepared by the U.S. Environmental Protection Agency (EPA) for the state of Ohio.

Figure 1 identifies the supporting documents. Document #2 provides an overview of the study methodology and illustrates the depth of analysis contained in the study.

Impact Studies

Documents #3 and 4 are economic impact analyses of the utility and industrial sectors in Ohio. These reports address impacts on prices, output, employment and financial viability. Document #5 summarizes the energy impacts of the regulation in terms of the level of energy demand, shifts from coal to oil likely to occur as a result of compliance with the regulations as well as shifts in coal production patterns. In particular, this report focuses on whether coal production in Ohio, which is generally high in sulfur content, will be adversely impacted.

Cost Minimization

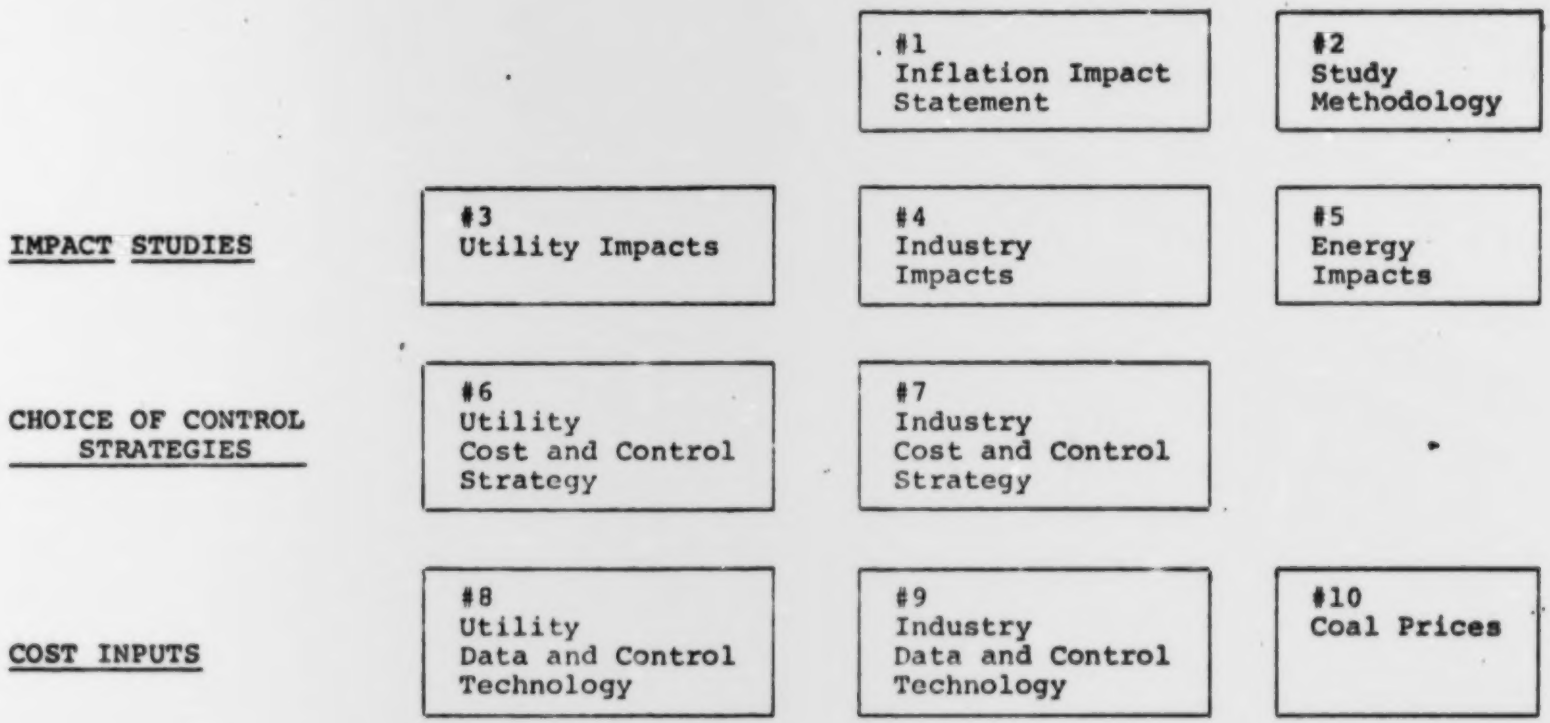
Documents #6 and 7 present the methodology for estimating costs of compliance and the choice of pollution control strategies. For both utility and industry, these supporting documents outline the cost minimizing strategies which provide the basis for the economic and energy impacts discussed in documents #3 - 5.

Cost Inputs

These final documents contain the basic data inputs to the study. Document #8 describes the pollution control technology options, their costs plus basic plant specific parameters which influence costs such as fuel consumption and boiler firing rates.

Figure 1

INFLATION IMPACT STATEMENTS SUPPORTING DOCUMENTS



Document #9 contains similar data on the industrial sector. Document #10 presents the derivation of coal prices employed in this study and used in both the industry and utility sector analysis. The focus is on the price premium of low versus high sulfur coal.